OPTICAL DISTANCE MEASURING DEVICE

Field of the Invention

5   The present invention refers to an optical distance detecting or measuring device, comprising a light source with an emitting optic for projecting a light beam according to the axis of the emitting optic onto a target to be measured and a first detector defining the receiving axis
10 contained in the same reference plane as the emitting axis.

Background of the Invention

      Prior art devices including optical reflection sensors
15 with background suppression or distance measuring devices generally make use of the triangulation principle described by Figure 1. Beyond a maximum distance, the operation of the sensor is impaired due to the fact that the angular sensitivity decreases with the distance. When attempting to
20 increase this distance, the result is an enlargement of the dead zone which excludes an operation in the proximity of the sensor.

      In order to adapt this limited measuring range to
25 varying situations, certain manufacturers use an adjustable mirror that allows the best adaptation of the measuring range. Such a solution is e.g. described in US Patent No. 3,759,614.

30   Other solutions are known as well: Different references such as GB-A-2 069 286 and DE-A-196 19 308 suggest a pulsed emission and an analysis of two receiver channels. DE-A-24 55 733 alternatingly uses two lighting optics located in the same plane. DE-C-40 04 530, DE-C-40
35 40 225, DE-C-41 40 614 as well as DE-C-198 08 215 suggest

that a plurality of alternatingly emitting light sources are
provided in the same optical channel. The receiver channel
is formed by multiple detectors or by a position-sensitive
detector, e.g. PSD, the electronic circuit being capable of
5 processing the signals corresponding to each one of the
light sources to obtain information concerning the distance
to the target. A sophisticated treatment of this
information allows a slight extension of the range of the
measuring system.
10

However, the inherent limitations of the principle of
triangulation between elements that are situated in the same
plane as defined by the optical axes of the emitting and
receiving systems do not allow a substantial improvement of
15 the performance with respect to distance, linearity, and the
dead zone. Thus, in the case of a measuring sensor or of a
background suppression triangulation sensor, a calculation
of the ratio between the maximum detection distance and the
minimum distance of the measuring range yields a quality
20 number that is rarely greater than 5. On the other hand,
such detectors are very often sensitive to the amount of
light reflected by the target, which depends on the texture
and the color of the latter.

25   On the background of this prior art, a first object of
the present invention consists in substantially improving
the results of measurements by triangulation without the
need for complex analyzing circuits. This is accomplished
by an optical distance detecting or measuring device wherein
30 said device comprises at least a second detector that is
aligned with the first detector on an axis contained in a
plane that is inclined at an angle with respect to the
reference plane, said angle being comprised between 10° and
170°.
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A second object is to allow the realization of efficient measuring or background suppression sensors having small dimensions. This is accomplished by an optical distance detecting or measuring device, comprising a light

5 source and receivers, wherein the light source emits light pulses of different intensities that are intended alternatingly for each one of said receivers, the emitted intensities being regulated in such a manner as to produce signals having identical amplitudes or corresponding to a

10 predetermined function on the receivers, and an optical distance detecting or measuring device, comprising a sensor with a single lens including distinct emitting and receiving sectors, each sector being provided with a prism for focusing the light beams on the emitting and the receiving

15 elements, respectively.

Brief Description of the Drawings

The invention will be explained in more detail

20 hereinafter with reference to the accompanying drawings.

Figure 1   schematically shows the known measuring
              principle by triangulation;

25 Figure 2   describes the disposition of the measuring
              elements of the invention;

Figure 3   illustrates the values measured in function of
              the distance;

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Figures. 3A-3C are sectional views according to C-C, C1-C1,
              and C2-C2 in Figure 3;

Figure 4   shows the performance of the invention;

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Figure 5   schematically describes a simple embodiment of a
              device of the invention;

Figure 6   shows the realization of a compact sensor;

Figure 6A   shows a sectional view according to line F-F of
              the sensor of Figure 6; and

Figure 7   describes a variant of the embodiment of Figure
              2.

Detailed Description of the Invention

In Figure 1, illustrating the known measuring
principle by triangulation, shows light source 21 and
emitting optic 22 which project the beam onto target C that
is to be measured, thereby defining optical emitting axis e.
The light resulting from the diffusing reflection of target
C is focused on receiver 23 by lens 24. These two elements
define the reference axis r of the receiving system. The
axes of emitting optic e and of receiving optic r define a
plane in which all elements of this triangulation measuring
system are situated. Thus, an additional receiver 25 is
disposed near the reference receiver. It determines a new
receiving axis r1, also comprised in the same plane, which
extends the measuring range to C1.

The detecting system is thus formed of an assembly of
two or more detectors, and the same detecting function can
also be realized by a position-sensitive detector such as
PSD. The electronic circuit processing the signals
delivered by the detectors will determine the position of
the luminous impact and deduce the information of the
measured distance from that position.

The performance of such an arrangement depends on the
number of detectors and on the space therebetween, as well
as on their position with respect to the emitting optic.
With regard to basis X, which is defined as the distance
5 between the emitting optic and the receiving optic, it
appears that the measuring range M is limited and the dead
zone Z is large. Linearity is affected by the sensitivity
of the detectors to angular variations of the incident beam,
which decreases as the distance from the target increases.
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The present invention provides a different arrangement
of the detectors. The novel arrangement is shown in Figure
2, illustrating light source 1 and the lens of emitting
channel 2, which define the optical axis Oe of the emitting
15 system. Reference detector 3 and lens 4 define the
reference axis Or of the receiving system. These two axes
of the emitter and the receiving system determine reference
plane A. Plane C represents the target that is to be
detected or whose distance is to be measured.
20

It will be shown that when an additional detector 5,
defining a new receiving axis Or1, is situated in a plane B
that is inclined at an angle α with respect to reference
plane A, the intensities measured by the detectors allow to
25 obtain a highly linear information in function of the
distance in a large measuring range. The optimum value of
inclination α is 90°, but any other inclination α between
10° and 170° is advantageous. In the text, reference will
be made to 90°, while it is understood that the angle α may
30 be different.

Figure 3 schematically shows the envelopes of the
beams in the suggested arrangement. Envelope E of the
idealized emitting beam is shown in the case of a large
35 distance focusing of source 1 and of lens 2. After lens 2,

the envelope is cylindrical. The envelopes of receiving beams R and R1 are also illustrated in a cylindrical form. Emitting source 1 and reference receiver 3 are situated in the principal plane and aligned on axis a while the two

5 receivers 3 and 5 are aligned on an axis b that is perpendicular to axis a.

Figs. 3A to 3C show the intersections of the three beams for three positions of the target and allow to

10 determine the ratios between the luminous intensities measured by the two receivers by means of an area calculation.

If the ratio between the intensity of principal

15 receiving beam i and that of secondary beam i1 is calculated and this ratio is represented in function of the distance d measured between the detector and the target, the diagram of Figure 4 is obtained. It appears that the variation of this ratio i1/i is linear in a large portion of the measuring

20 range. A calculus of the ratio between the maximum distance and the dead zone, as defined earlier in the description, yields a quality number of up to 10. The diagram of Figure 4 shows clearly that the first object of the present invention is attained, namely the improvement of the

25 measuring results by triangulation, i.e. a large measuring range, a very small dead zone, and a high linearity are obtained.

In order to obtain these results, it is important that

30 the envelope curves of the beams are as cylindrical as possible. This must be the case over a distance corresponding to the measuring range. To this effect, the real rather than the punctual dimensions of the source and of the detectors must be taken into account. The distances

35 between these components and the lenses must be adapted to

the focal distances in such a manner that the beams are as close to the cylindrical shape as possible.

5 A device realized according to this principle, comprising an emitter LED and two receiving photodiodes, is suggested and schematically described by Figure 5 as an example of a simple embodiment. The light pulses are emitted by LED 1 alternatingly for each one of photodiodes 3 and 5. In this exemplary embodiment, the photodiodes are
10 aligned on an axis that is perpendicular to the plane defined by the emitting axis and the reference receiving axis. The alternating emitting intensities E3 and E5 are regulated such that the respective amplitudes of the signals R3 and R5 measured by each one of the receivers are
15 identical or correspond to a predetermined function. The information concerning the distance results from the ratio of the intensities E3 and E5 of the emitted light. This procedure offers the additional advantage of a very low sensitivity of this device to the color of the target.
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The described principle, according to which the alternating emitting intensities E3 and E5 are regulated such that the respective amplitude of the signals R3 and R5 measured by each one of the receivers are identical or
25 correspond to a predetermined function, applies both to an optical device where the photodiodes are situated in the same plane as the emitter diode or in an inclined plane.

However, the advantage of this principle combined with
30 the advantage of the inclined plane results in a particularly advantageous device.

An example of a compact sensor that is adapted for realizing a device according to Figure 5 is described by
35 Figure 6. Sensor 10 comprises a small enclosure D including

the optical components and the electronic circuits E. Also
visible are emitter LED 1 and the two photodiodes 3 and 5,
which are arranged on a perpendicular axis, as well as the
principle of the emitter and the receiving optics using the
5   same lens 8. This is possible thanks to the two prisms 9,
which are arranged behind the lens and allow a spatial
separation of the emitting and of the receiving beam. The
latter principle applies both to an optical device where the
photodiodes are situated in the same plane as the emitter
10 diode or in an inclined plane. Such a compact sensor may
also be realized and applied in other distance measuring
devices comprising one or a plurality of emitters and one or
a plurality of receivers of the prior art.

15   The solutions according to Figs. 5 and 6 show that the
second object of the present invention is attained, i.e. the
realization of a sensor of small dimensions in which the
optical and electronic assemblies required for its operation
are integrated. The invention thus allows an improvement of
20 the performance of current sensors while conserving their
size, and also the realization of smaller and more
performing sensors.

The preceding demonstration of the performance of a
25 measuring system based on one emitter and two detectors may
be extended to a greater number of detectors and also to a
position-sensitive detector such as PSD, whose axis of
sensitivity may be situated either in the plane A defined by
the emitting axis and the reference receiver axis, or
30 inclined at an angle α, preferably at 90°, with respect to
the plane A.

The principle described above is also applicable in
the case of the measuring system of Figure 7, where the
35 emitting and the receiving elements are inverted as compared

to the system described in Figure 2. This system comprises
two or several emitting sources 1 and 7 aligned in a plane B
that is inclined at an angle α, preferably at 90°, with
respect to plane A which is defined by the reference
5   emitting axis Oe and the receiving axis Or extending between
receiver 3 and optic 4 for focusing the diffuse light on the
receiver.

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